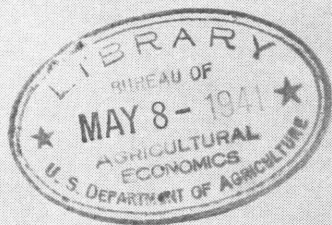


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DISEASES OF RICE



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OF AGRICULTURE

The principal and minor diseases of rice and their effect on stands, yields, and quality are briefly described in the following pages, with suggested methods of control.

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DISEASES OF RICE¹

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INTRODUCTION

Rice was grown in the South Atlantic States for a period of nearly 200 years before any serious disease was reported. About 1905 diseases were found following the development of the rice industry in southeastern Arkansas. In 1906 blast threatened the crop in South Carolina, and a study of this disease was begun. At present the most serious diseases of rice in the United States are seedling blight, leaf and leaf-sheath spots, leaf smut, stem rot, kernel spots, kernel smut, straighthead, and "white-tip" (chlorosis). Most of these diseases occur also in other rice-growing countries of the world.

Most of the diseases that affect the growing crop probably came into the United States on seed introduced from foreign countries prior to the establishment of the plant-quarantine laws. Fifty-two species of organisms (fungi) have been found on rice plants in this country, but some are not known to cause disease. Although most rice diseases are caused by fungi, some are caused by unfavorable soil or weather conditions, or by small worms (nematodes).

Fungi are moldlike plants, such as those that develop on stale bread, that grow in the soil or in plant tissues. Many of them are able to live on dead plants during the periods of the year when there are no live plants on which they can grow. Some produce spores or other structures (sclerotia), more or less comparable with the seeds of higher plants, to carry them over adverse periods of cold or dry weather. These are the means by which the disease (fungi) is spread from one plant to another.

The cause, symptoms, and means of control of the more important rice diseases are discussed in the following pages. The arrangement of the diseases is as nearly seasonal as possible; that is, the seedling diseases are discussed first, then leaf and sheath spots, followed by stem rots and kernel diseases.

¹ Cooperative investigations of the Division of Cereal Crops and Diseases, Bureau of Plant Industry, and the Arkansas, Louisiana, and Texas Agricultural Experiment Stations.

SEEDLING BLIGHT

Seedling blight of two types occurs on rice in the Gulf States area. In one type apparently healthy seedlings are attacked at the ground line by a fungus ² that produces an abundant white growth (mycelium) over the surface of the soil and on the lower portion of the plant. This disease is most common during periods of moist, warm weather after the rice seedlings emerge and before irrigation. The affected seedlings are discolored slightly, and a whitish cottony growth of the fungus appears at the soil surface. Later, small, round, light-brown seedlike fungus bodies may be found on the lower portions of the seedlings. Many severely affected seedlings are killed by the disease, and stands are thus reduced. Immediate submergence of the land checks the development of the disease and gives the less severely attacked seedlings a chance to recover and develop into normal plants.

Seedling blight may also be caused by three other fungi.³ Many of the seedlings that are attacked by these fungi fail to emerge from the soil during cool, damp weather and, as a result, marked reduction in stands may occur.

Experiments indicate that the use of some of the commercial dusts ⁴ for treating the seed before sowing provides considerable protection for the seedlings and helps to get increased stands, particularly of early sown seed. The improved stands, however, have not necessarily resulted in increased yields.

ROOT KNOT

Root knot is caused by a kind of minute worm known as a nematode,⁵ which also attacks many other plants. It was found on rice roots in one field in Arkansas in 1933 and has also been found there since. The infected parts of the roots of the seedlings become much enlarged and deformed, and stop growing (fig. 1). The above-ground parts of affected plants become somewhat dwarfed, turn yellow, and many of them die. This disease of rice is of minor importance.

WHITE TIP

A disease known as white tip, in which the leaf tips turn white, occurs on rice in Arkansas and Louisiana, and to a limited extent in Texas. It also occurs on rice in Puerto Rico on alkaline soils. The disease appears to be caused in part by an alkaline condition of the soil that probably prevents the plants from obtaining sufficient iron and perhaps other elements from the soil.

White tip symptoms appear from June to August, when the rice plants are from 2 to 3 months old. Blue Rose rice affected by white tip is shown in figure 2.

The whitening of one-half to one and one-half inches of the leaf tips is observed first, but the whitening often spreads farther on such leaves as the plant becomes older. The areas affected are white or greenish white and are of a papery texture. Affected leaves are

² *Sclerotium rolfsii* Sacc.

³ *Helminthosporium oryzae* van Breda de Haan, *Curvularia lunata* (Wakker) Boedijn, and *Trichoconis caudata* (Ap. and Str.) Clem.

⁴ The dust sold under trade name New Improved Ceresan should be used at the rate of one-half ounce per bushel.

⁵ *Heterodera marioni* (Cornu) Goodey.

shown in figure 3. In addition to the loss of green color in leaf tips, sheath twisting is associated also with this type of injury that results in imperfect emergence of the heads and deformed grain. In severe cases the plants are dwarfed, and head formation may be prevented.

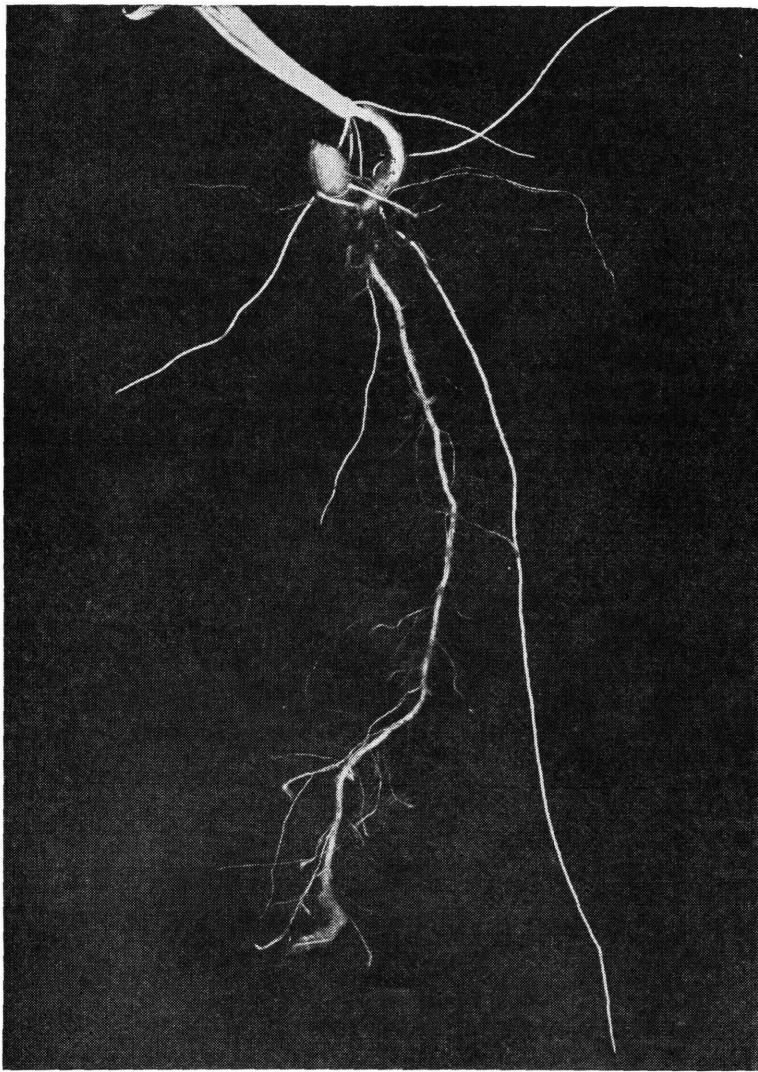


FIGURE 1.—Root knot of rice. Twice natural size.

Results of experiments in Arkansas indicate that the white tip condition may be partly corrected by acidifying alkaline soil with sulfur or sulfuric acid, but such treatment may not be practical on farms. In Louisiana the use of nitrogenous fertilizer appears to be advantageous.

LEAF SPOTS

BROWN SPOT

Brown spot is one of the most serious fungus⁶ diseases of rice in the southern United States. It also occurs in Japan, CochinChina, China, Dutch East Indies, the Philippines, Peru, Colombia, Italy, and India. The disease is found in Louisiana and Texas and, to a lesser extent, in Arkansas and attacks the seedlings, leaves, "necks," hulls (glumes), and kernels of rice. It may attack the seedlings and cause seedling blight at any time until they attain a height of about

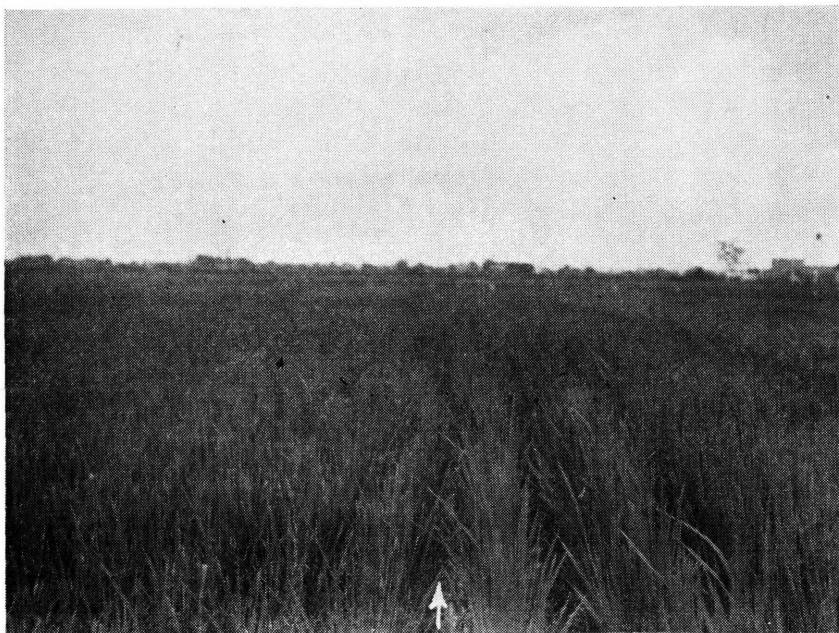


FIGURE 2.—White tip of Blue Rose rice (at left) at Rice Experiment Station, Crowley, La. Note that the variety to the right of the arrow is not affected.

4 inches. Brownish discolorations first appear on the sheaths between the germinated seed and the surface of the soil or on the roots. Badly affected seedlings die because their upper parts are cut off from the roots by the girdling action of the fungus, and stands of rice are thus reduced.

On the leaves the spots are circular to elongate and usually are most abundant in August and September. The small spots are dark reddish brown, and the larger ones have dark reddish-brown margins and grayish centers (fig. 4). On severely affected plants the leaves may dry up before the crop is fully mature, and the yield and quality of the rice may be affected seriously.

The brown spot fungus also causes the condition known as rotten neck, similar to that caused by the blast fungus (fig. 5), in which the upper part of the affected stem and branches of the head may break over. The tissues of such infected parts turn brown, shrivel, and die,

⁶ *Helminthosporium oryzae* van Breda de Haan.

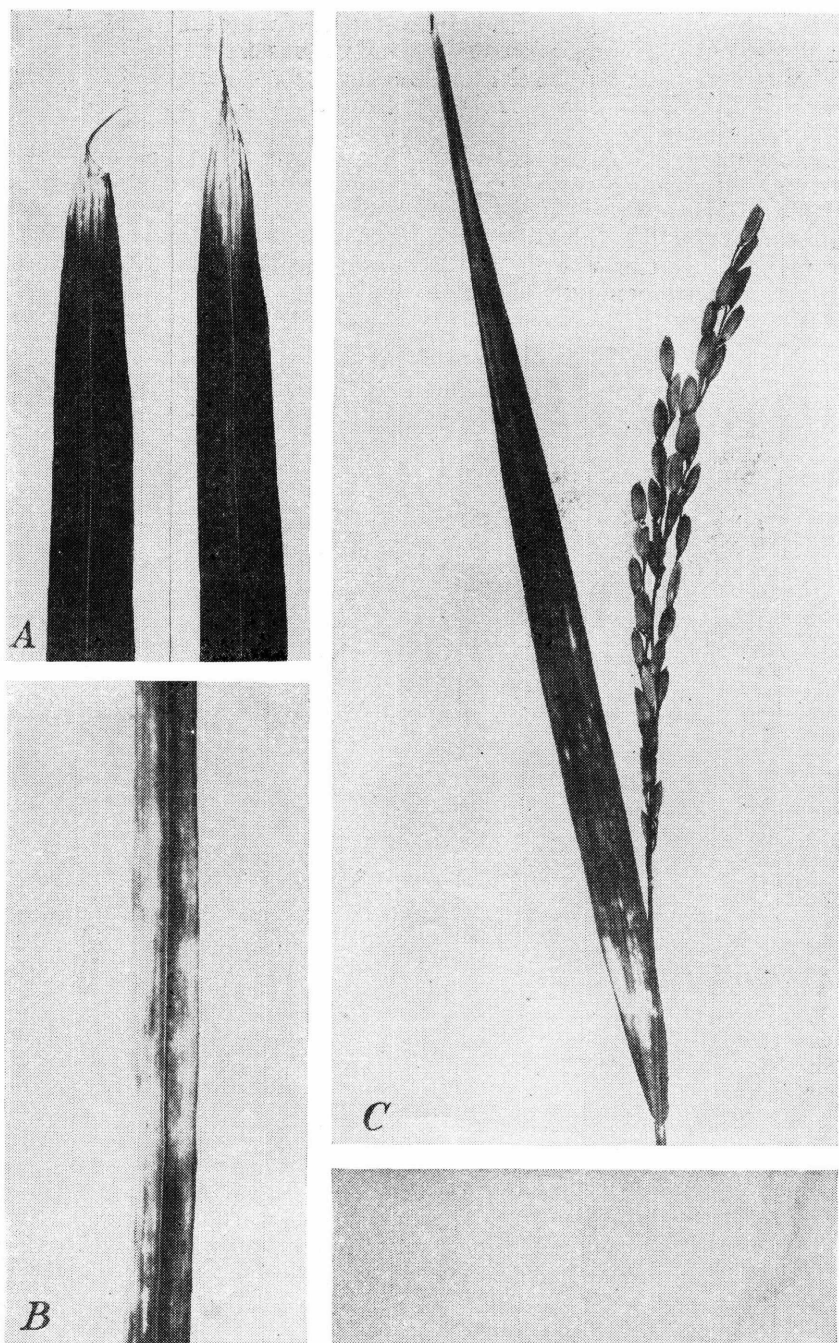


FIGURE 3.—A, White tip; B and C, absence of green color at the base and middle of Blue Rose rice leaves.

and the weight of the heads or parts of heads breaks the stalks at such weakened points, allowing the heads or portions of the heads to hang down. If the "necks" or branches of the heads break before the rice is mature, the kernels are light in weight and of inferior quality.

Spots on the hulls (glumes) when they are still green look much the same as those on the leaves, and the brown edges of the spots are still visible after maturity (fig. 4, *B*). Spots may occur on the kernel under the spots on the hulls, or they may be along the sides of the kernel. The latter usually occurs when the hulls fail to interlock properly after blooming and thereby leave part of the kernel exposed. Entire infected kernels may be brown, or only portions of them may

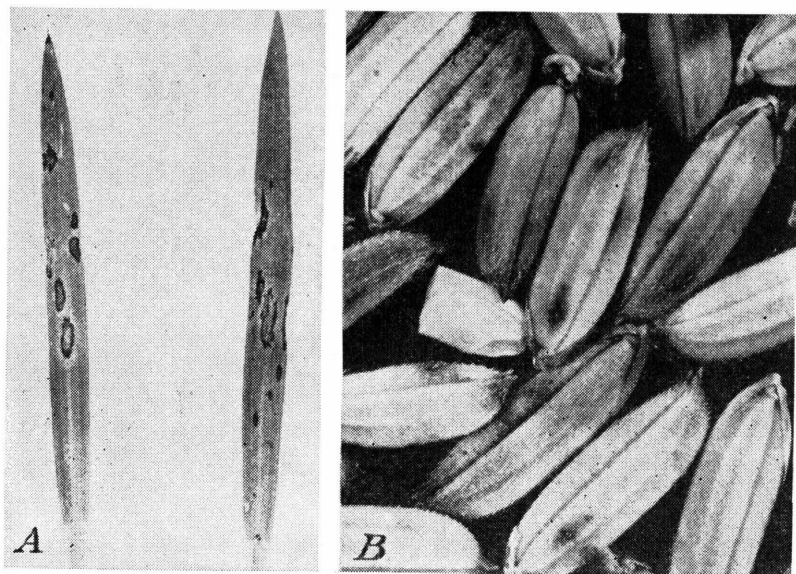


FIGURE 4.—*A*, Brown spot on leaves of rice from inoculations in the greenhouse. Natural size. *B*, Brown spot on the hulls of Fortuna rice from Texas. Three times natural size.

be discolored. The term "pecky rice" is applied to kernels that are discolored. The discoloration affects the milling quality of the rice as well as its appearance. Pecky rice may be due also to injury of the kernels by other fungi or by insects.

Seedling blight resulting from the brown spot disease may be controlled in part by treating the seed.⁷ However, the brown spot fungus also is carried in the soil on plant refuse and occurs on wild grasses in or near the fields and for this reason seed treatment gives only temporary protection to the young plant. The use of resistant varieties probably is the best means of controlling this disease.

BLAST

Blast, a fungus⁸ disease, has at times been serious in most of the rice-growing States, with the exception of California. Blast prob-

⁷ See footnote 4, p. 2.

⁸ *Piricularia oryzae* Br. and Cav.

ably is the most serious disease of rice in Japan and it occurs also in China, India, the Fiji Islands, Italy, Bulgaria, Argentina, Brazil, and the Union of Soviet Socialist Republics. This disease is characterized by the breaking over of the "necks" and branches of the heads (fig. 5), by the blighting or blasting of entire heads, and by spots on the leaves and hulls. The leaf spots tend to be long and narrow on young leaves (fig. 6) and more or less circular in outline on old leaves.

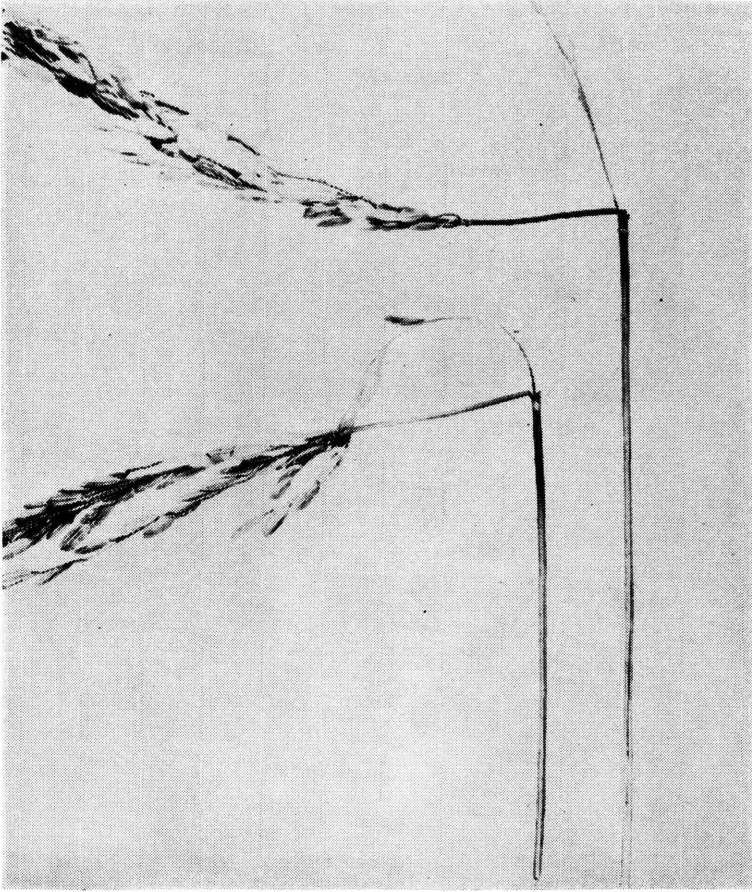


FIGURE 5.—Rotten neck symptoms of the blast fungus on Early Prolific rice. One-half natural size.

The circular spots usually can be found on the leaves even after they are dead. The leaf spots caused by the blast fungus are similar in appearance to brown spot and, in some cases, it is almost impossible to distinguish them except by microscopic examination. The joints (nodes) of the stem also may be attacked.

Infected areas on the stalk and branches of the heads are dark brown. The stalk may break over at the infected joints, or the heads or parts of heads may break over where infections occur on the neck or branches of the heads. This tendency may differ greatly with different varieties.

Rice plants may be attacked by the blast fungus while they are young, prior to irrigation or during the period after the water has been drained from the field. Under such attacks the leaves of infected plants wither and dry, and the sheaths turn brown. Infected areas occur at the junction of leaf blade and leaf sheath. This has not been observed in the brown spot disease and may serve to differentiate the two diseases where this symptom may be found. A severe

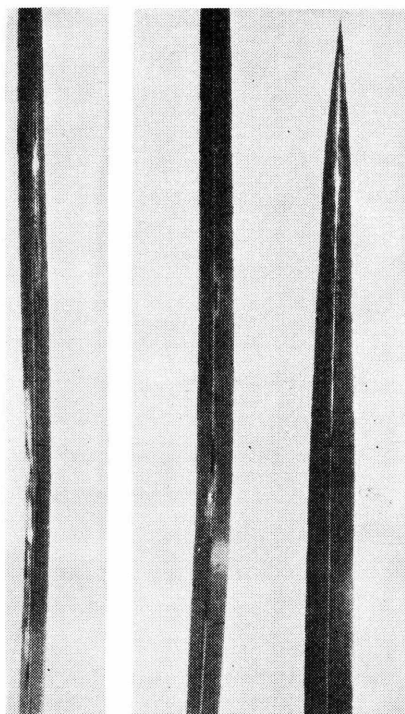


FIGURE 6.—Leaf spots on young rice leaves artificially inoculated with blast fungus in the greenhouse. Natural size.

infection by this disease may reduce yields and lower the market value of the rice.

The blast fungus also attacks crabgrass⁹ from which the infection may spread to rice. The fungus lives over on crabgrass or rice straw in the field and serves as a source of infection of rice the following season. Severe outbreaks of blast on newly cleared or newly broken land unquestionably result from infected wild grasses that were growing on the land before it was sown to rice.

Blast injury during early growth of the rice plants may be reduced by submergence of the land as soon as the leaf spots become evident. The breaking of the stalk and rachis may best be controlled by developing varieties that will not tend to break over even though infected. The excessive use of fertilizers of high nitrogen content should be avoided in fields in which blast has been found and on land that has not been recently cropped to rice.

⁹ *Digitaria sanguinalis* (L.) Scop.

NARROW BROWN LEAF SPOT

Narrow brown leaf spot is a fungus¹⁰ disease that was the most widespread leaf spot on rice in Arkansas, Louisiana, and Texas from 1934 to 1938. This disease occurs in Brazil, Argentina, Japan, China, Dutch East Indies, Burma, Dominican Republic, and Puerto Rico. The spots, which occur on the leaves, are long and narrow

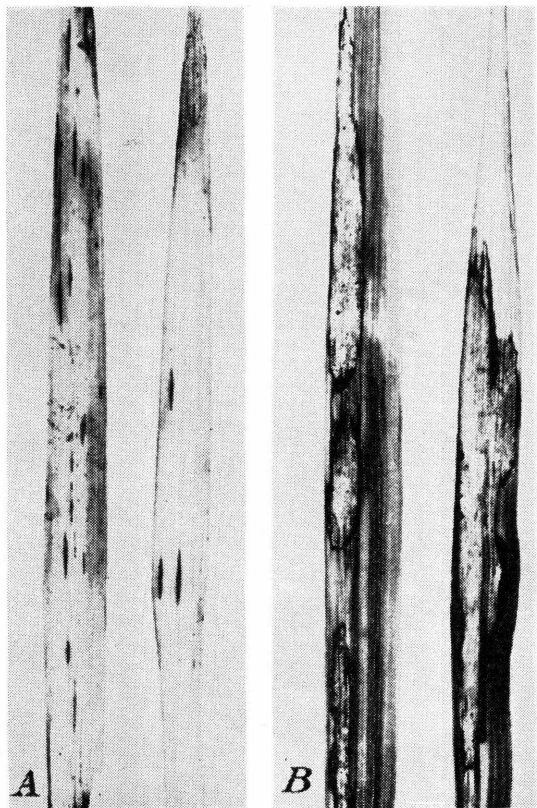


FIGURE 7.—A, Narrow brown spot of rice leaves; B, brown bordered spot of rice leaves. Natural size.

(fig. 7, A) and, therefore, are easily distinguished from those produced by other fungi. Usually the narrow brown spots do not appear on plants in great abundance in the field until late August and September. The bleached, dead center, common to other leaf spots of rice, occurs only in very susceptible varieties. Injury to affected plants is confined mainly to the reduction of leaf area. Marked differences in varietal susceptibility indicate that this disease may be controlled by the selection and use of resistant varieties.

BROWN-BORDERED LEAF SPOT

Brown-bordered leaf spot is a fungus¹¹ disease that occurs on rice in Arkansas, Louisiana, and Texas. It occurs also on rice in Japan

¹⁰ *Cercospora oryzae* Miyake.

¹¹ *Phyllosticta glumarum* (Ell. and Tr.) Miyake.

and the Philippines. The spots are at first light brown and their centers become lighter as they enlarge (fig. 7, *B*), and extend from the midrib to the margin of the leaf. The fungus bodies (pycnidia) in which the spores are produced, visible only under a magnifying lens, are light brown. Most commercial varieties of rice are rather resistant to this leaf spot, and it has never been found to cause any great amount of damage.

LEAF SMUT

A leaf smut of rice, caused by a fungus,¹² occurs in Arkansas, Louisiana, and Texas. It is also known to occur in Argentina, the

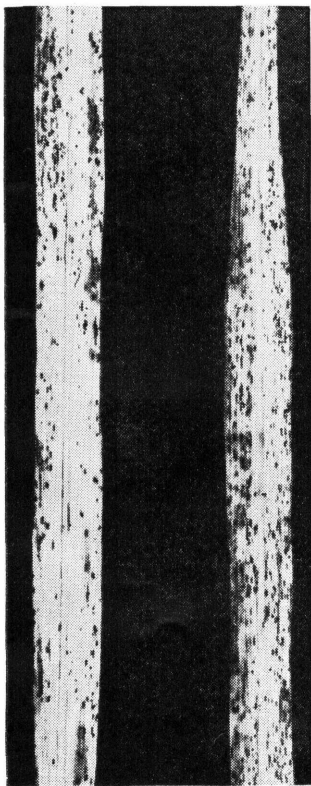


FIGURE 8.—Leaf smut of rice. Natural size.

Philippines, and Japan. This smut is found in July, August, and September on the leaves, leaf sheaths, and occasionally on the upper portion of the stalk, where it shows as small black spots. These spots (sori) contain the black spores of the smut fungus. The spots at first are slightly raised, but later the leaf tissues over the sori break open lengthwise and allow the spores to escape. Smut spots on the leaves are shown in figure 8. In this disease, as in the narrow brown leaf spot, the injury to the plant consists in reducing the leaf area.

Varieties differ in susceptibility to leaf smut, and, therefore, the use of the more resistant types will help to control the disease.

¹² *Entyloma oryzae* H. and P. Sydow.

BORDERED SHEATH SPOT

Bordered sheath spot is a fungus¹³ disease of rice that occurs rather commonly in Louisiana and Texas and to some extent in Arkansas and California. The disease occurs chiefly on the sheaths above the water line and also may occur on the leaves. The spots are more or less irregular in outline. Their centers, particularly between the veins, are cream colored, and their outer borders are rather broad and dark reddish brown. The inner edges of the borders are usually jagged (fig. 9).

The discoloration of the sheaths produced by this disease is not so intense as that caused by the other sheath diseases. The disease

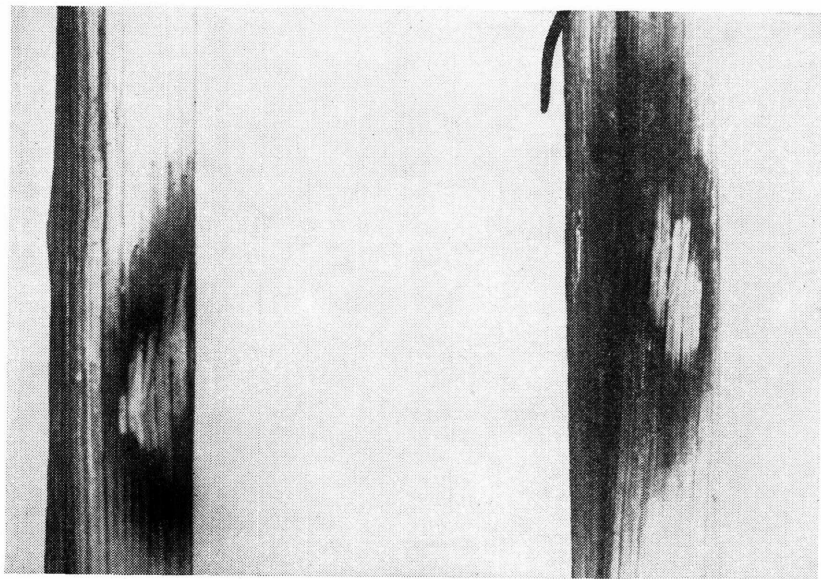


FIGURE 9.—Bordered sheath spot of rice. Three times natural size.

apparently is usually of minor importance on rice and is known to attack sugarcane and Bermuda grass as well as rice.

Various diseases of rice caused by the genus *Rhizoctonia* have been reported from India, China, Japan, and the Philippines.

SHEATH ROT

BLACK SHEATH ROT

Black sheath rot is a fungus¹⁴ disease originally found on rice in Arkansas. Later it was found also in Louisiana, but not in Texas or California. In the early stages of the disease, it is difficult to distinguish from stem rot because blackening of the sheaths occurs in both. The disease usually appears on rice in late July and August. The tissues of the sheaths attacked by the fungus soon begin to rot, however, so that in severe cases the leaf sheaths are entirely rotted away at the water line, but the stems are rarely attacked as in stem rot.

¹³ *Rhizoctonia oryzae* Ryker and Gooch, *R. solani* Kühn, and *R. zeae* Voorhees.

¹⁴ *Ophiobolus oryzinus* Sacc.

The fungus overwinters on rice stubble and also on the sheaths of the cattail.¹⁵ Leaf sheaths of rice plants grown in the greenhouse with various degrees of rotting are shown in figure 10.

This sheath rot, even though widespread in Arkansas, is of rather minor importance. This fungus has also been found in Italy, but no report of a disease caused by it has been made.

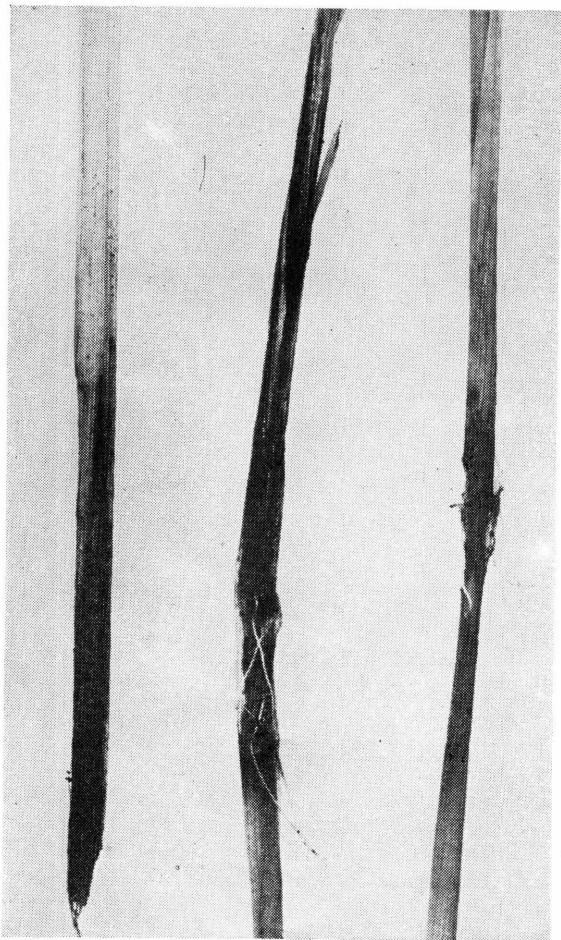


FIGURE 10.—Black sheath rot of Blue Rose rice. Natural size.

REDDISH-BROWN SHEATH ROT

Reddish-brown sheath rot is a fungus¹⁶ disease, somewhat similar to the black sheath rot, that occurs on rice in the South, but it is not very common. Late in the season the lower leaf sheaths become reddish brown and somewhat rotten, although rotting is not so severe as in the black sheath rot. Irregular dark seedlike fungus bodies are embedded in the sheaths and characteristic spores are found on the surface of the spots. It is not a serious disease on rice.

¹⁵ *Typha latifolia* L.

¹⁶ *Helicoceras oryzae* Linder and Tullis.

STEM ROT

Stem rot is one of the more important diseases of rice. It is caused by either of two species of fungi,¹⁷ both of which may be found on the same plant. The disease occurs in Arkansas, Louisiana, Texas, and California, but it is more widespread and causes greatest losses in Arkansas and Louisiana. Stem rot has been reported from Italy, Bulgaria, Portugal, India, Cochinchina, Ceylon, Japan, and the Philippine Islands.

The earliest signs of the disease may be seen late in July or early in August, when small, black, discolored areas appear on the leaf

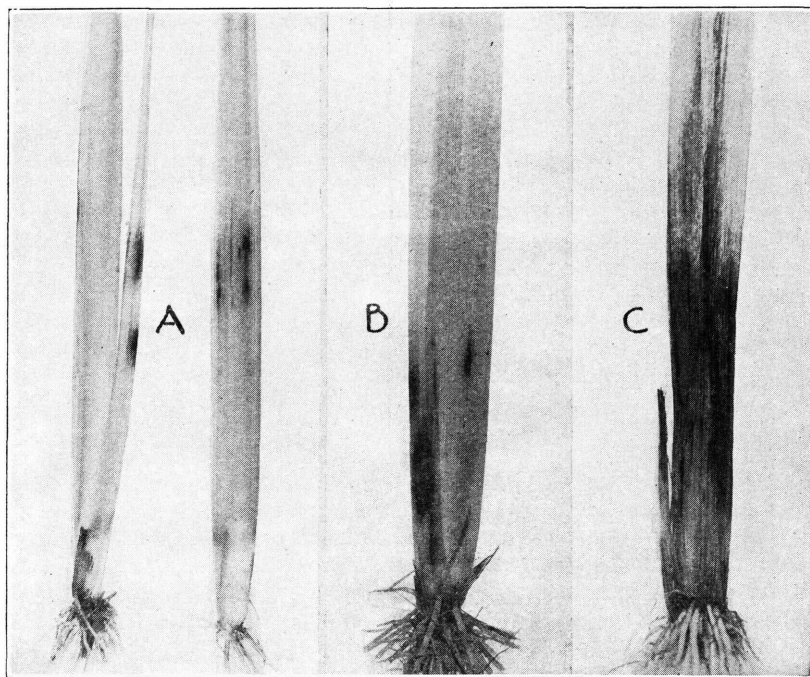


FIGURE 11.—Stem rot on outer sheaths of Blue Rose rice plants showing various stages of development. A, Early stage; B and C, progressively later stages showing severe rotting in C. Natural size. (Illustration courtesy of Arkansas Agricultural Experiment Station.)

sheaths at the surface of the water or slightly above. When the spots on the lower outer leaf sheaths enlarge, the inner sheaths also are invaded and discolored. When the infection reaches the stalk, numerous small, shiny, black oppressed bodies are produced on it by the fungus. Dark masses of fungus threads then develop on the stalk, and longitudinal brown to black streaks appear in the stalk above and below these masses. Various stages of development are shown in figure 11. Soon the fungus threads may be found in the interior of the stalk, as a cottony white mass, and by the time the rice is nearly mature, numerous small black seedlike fungus bodies (sclerotia) may be found in the sheaths and stalks. It is at this stage that the stalks

¹⁷ *Leptosphaeria salvinii* Catt. and *Helminthosporium sigmoideum irregulare* Cralley and Tullis.

break over and the plants lodge (see title-page illustration). Plants infected at an early stage of development produce only lightweight heads. Many of the larger heads on lodged plants are lost when the rice is harvested with a binder because they hang so near the ground that they cannot be saved.

The fungus lives over winter as seedlike fungus bodies (sclerotia) in stubble and soil, and these bodies floating on the water produce the primary infection on the sheaths of plants the following summer. Primary infection may also be produced from the fungus living over on barnyard grass ¹⁸ and on southern wildrice ¹⁹ growing in and near fields and in irrigation ditches. The latter grass is found rather commonly, especially in Louisiana. Secondary infection by spores (conidia) produced on the sheaths occurs after the fungus has become established on the rice plant. Sclerotia that will germinate have been recovered from infested soil as much as 3 years after the land was last cropped to rice.

The most satisfactory method of control is to drain the water from infected fields before the infections have reached the rice stalk. Enough water should be added from time to time thereafter to keep the soil saturated but not submerged. Such treatment results in a slight reduction in yield. However, in badly infected fields such treatment may result in higher yield, because lodging can thus be prevented and all the rice can be harvested. No highly resistant varieties of commercial value are available.

KERNEL DISEASES

KERNEL SPOTS

A number of types of kernel spots are found on rice. One type has already been referred to under the brown spot disease (p. 4). Another, which is known as "black kernel," is caused by a fungus ²⁰ that frequently blackens the entire kernel inside and outside, and small, slightly raised, seedlike fungus bodies dot the surface of the kernels. In other cases the affected kernels show only surface discoloration. Another fungus ²¹ kernel spot also produces discolored kernels that are pinkish or reddish in color.

Rice kernels that are severely infected with any of these kernel-spot fungi usually germinate poorly and rarely produce good plants.

Many of the diseased kernels are chalky in texture and, therefore, are broken when the hulls are removed or later in the milling process; thus, the yield of head rice may be appreciably reduced. When the diseased kernels are not chalky but discolored throughout, the discoloration cannot be removed in milling. Another type of kernel spot is caused by the rice stinkbug, *Solubea pugnax* Fab., which punctures the developing kernels with its beak, feeds on the contents, and apparently facilitates the entrance of spot fungi. This kernel spot affects the milling quality in much the same manner as those referred to previously. The presence of any of these types of discolored kernels (fig. 12) in milled rice reduces the grade. Kernel spots caused by some of these fungi have been reported from Indochina and Japan.

¹⁸ *Echinochloa crusgalli* (L.) Beauv.

¹⁹ *Zizaniopsis miliacea* (Michx.) Doell and Aschers.

²⁰ *Curvularia lunata* (Wakker) Boedijn.

²¹ *Trichoconis caudata* (Ap. and Str.) Clem.

KERNEL SMUT

Kernel smut of rice, caused by a fungus,²² occurs occasionally in Arkansas, Louisiana, and Texas. This disease occurs also in Japan, China, the Dutch East Indies, and the Philippine Islands. It reduces the yield and in some cases damages the quality very materially because of the black or gray color of the milled rice. This discoloration is caused by the spores of the fungus that are liberated when the rice is milled. Affected kernels differ in the degree to which they are attacked. In the most severe cases the entire starchy part of the

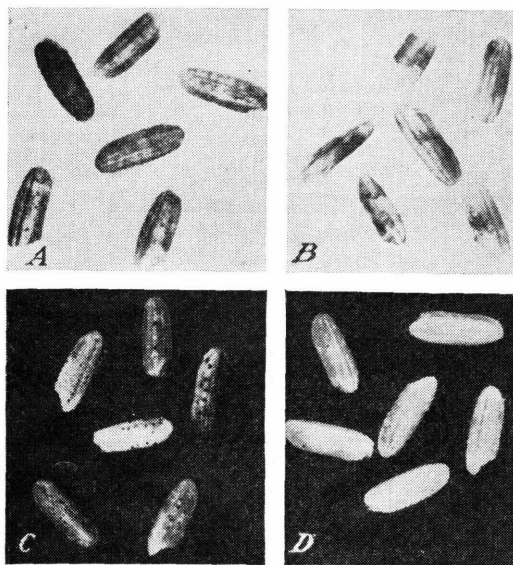


FIGURE 12.—Kernel spots on Fortuna rice from near Katy, Tex., produced by fungi: A, *Curvularia lunata*; B, *Helminthosporium oryzae*; C, *Trichoconis caudata*; D, normal kernels. Twice natural size.

kernel (endosperm) becomes a black mass of spores. In other cases, a portion of the kernel may be normal. The smutted part is nearly always at the germ end of the kernel. Severely smutted kernels are light in weight and float in water. The partly smutted kernels, however, sink in water as do the normal kernels. It is, therefore, not possible to make a complete separation by flotation in water.

The smutted kernels (fig. 13) are not noticeable until the rice is mature. Usually not more than two to six smutted kernels are found on a head. Little if any swelling of the kernel is caused by the smut, and the most conspicuous symptom is the dark discoloration on the hulls of mature seeds caused by the black smut spores showing through the hull on the outside. The embryo (germ) is never smutted and will germinate even when the entire endosperm is reduced to a mass of smut spores.

Natural conditions in the field apparently check the disease. The commercial varieties now grown appear to differ in susceptibility to kernel smut. Usually the disease is of minor importance.

²² *Tilletia horrida* Tak

STRAIGHTHEAD

Frequently, vigorous dark-green, normal-appearing rice plants fail to set seed in many of the flowers. As a result, the heads remain

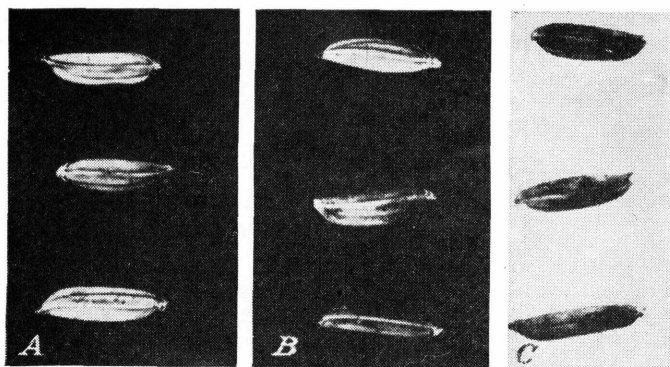


FIGURE 13.—Kernels of Rexoro rice infected with the kernel smut fungus: *A*, Healthy; *B*, partly smutted; *C*, entirely smutted. One and one-half times natural size.



FIGURE 14.—Straighthead of rice, right, compared with normal, left.

erect (fig. 14) instead of turning down as when they fill normally. This condition, known as straighthead, is most important on new land and on land that has not been cropped to rice for several years, on which a heavy growth of weeds and grass has been plowed under.

Areas so affected produce little or no grain and although this condition is not frequently encountered, it is a source of considerable loss when it occurs. Frequently large portions of fields are so seriously affected that the yield of grain is not sufficient to justify harvesting and threshing.

Land on which straighthead is likely to occur should be drained at least once and allowed to dry until the surface cracks before the rice is in the boot. It is very important that the soil become thoroughly dried on the surface for the treatment to be effective.

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<i>Bureau of Plant Industry</i>	E. C. AUCHTER, <i>Chief</i> .
<i>Rural Electrification Administration</i>	HARRY SLATTERY, <i>Administrator</i> .
<i>Soil Conservation Service</i>	H. H. BENNETT, <i>Chief</i> .